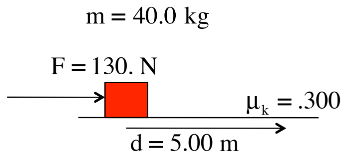
Problem 8.14



The force shown pushes a block over a frictional surface.

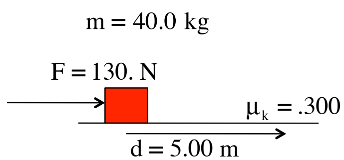
a.) How much work does the force do?

$$\begin{aligned} W_F &= |\vec{F}||\vec{d}|\cos 0^\circ \\ &= (130.\ N)(5.00\ m) \\ &= 650.\ J \end{aligned}$$

b.) What is the increase in *internal energy* due to friction (translation: how much work does friction pull out of the system and dump into the surrounding area in the form of heat)?

Noting that $f_k = \mu_k N = \mu_k mg$, we can write:

$$\begin{aligned} W_f &= |\vec{f}||\vec{d}|\cos 180^\circ \\ &= (\mu_k mg)(d)(-1) \\ &= -\left[(.300)(40.0\ kg)(9.80\ m/s^2)\right](5.00\ m) \\ &= -588\ J \quad (\Rightarrow \text{ energy increase to surrounding area} = 588\ J) \end{aligned}$$



c.) How much work does the *normal force* do?

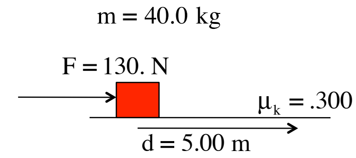
The normal force does not motivate the body to pick up or lose speed, so it does *no work*. The mathematical justification lies in the fact that the angle between the *normal* and the *displacement* is 90°, so:

$$\begin{aligned} W_N &= |\vec{N}||\vec{d}|\cos 90^\circ \\ &= 0 \end{aligned}$$

This is ALWAYS true. The normal *never* motivates a body's *speed* to change, though it may push a body out of straight-line motion—think banked curve on a freeway—which is a form of acceleration because the velocity *vector* is changing with the change of direction. (This kind of a case will be messed with later.)

d.) How much work does gravity do?

In this case, gravity is also at an angle of 90°, relative to the displacement vector, so in this case, gravity also does no work.



e.) What is the box's *change of kinetic energy*?

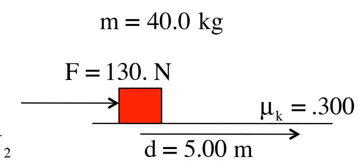
Although *Conservation of Energy* would work, in general when you see a question that asks for a *change of kinetic energy*, the first thing that should pop into your head is Work/Energy Theorem:

$$\begin{aligned} W_{net} &= W_F + W_f = \Delta KE \\ \Rightarrow \quad \Delta KE &= (650.\ J) + (-588\ .J) \\ &= 62.0\ J \end{aligned}$$

f.) What is the box's final speed?

This is a straight *Conservation of Energy* problem with friction and "F" acting as extraneous forces. That calculation is shown on the next page.

f.) (Cont'd)



$$\sum KE_1 + \sum U_1 + \sum W_{ext} = \sum KE_2 + \sum U_2$$

$$0 \quad + \quad 0 \quad + (W_F + W_f) = \frac{1}{2} m v_2^2 + \quad 0$$

$$\Rightarrow \quad v_2 = \left[\frac{2(W_F + W_f)}{m}\right]^{1/2}$$

$$\Rightarrow \quad v_2 = \left[\frac{2((650.\ J) + (-588\ J))}{(40.0\ kg)}\right]^{1/2}$$

$$= 1.76\ m/s$$